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STRATEGIC DEFENSE SYSTEM
SPACE-BASED ARCHITECTURE
FACT PAPER

BACKGROUND

February 9, 1990

The goal of the Strategic Defense Initiative remains unchanged: to conduct research to permit the President and the Congress, in consultation with our allies, to make an informed deployment decision in the early 1990s. President Bush, in fact, has stated, "I have taken another hard look at SDI and confirmed that the goal of the program -- providing the basis for an informed decision on deployment of defenses that would strengthen deterrence -- remains sound. We owe it to ourselves and our children to pursue that goal. I am personally and deeply committed to doing so."

While dynamic and dramatic global events have occurred in recent months, the Soviet strategic offensive nuclear ballistic missile arsenal has not diminished and, in fact, is being modernized. Secretary of Defense Dick Cheney pointed out recently that, "The fact of the matter is the Soviet strategic capability...[is] more robust, more modern today than when Mr. Gorbachev took office." In addition, proliferation of ballistic missile capabilities to other nations constitutes a growing threat. The need for a robust SDI research program is as compelling as it was seven years ago when President Reagan initiated the program. The Strategic Defense Initiative Organization (SDIO) continues to pursue that goal and has made remarkable progress.

In September 1987, the Defense Acquisition Board (DAB) recommended, and the Secretary of Defense approved, several Strategic Defense System (SDS) elements for entry into Milestone I of the acquisition process, a stage which involves demonstration and validation of each element. Those elements included a space-based interceptor (SBI); a ground-based interceptor; several Surveillance and Tracking Systems including Boost-phase (BSTS), Space-based (SSTS), and Ground-based (GSTS); and a Battle Management/Command, Control and Communication (BM/C^3) system. Collectively these elements became known as the Phase I system concept of the SDS.

COST

Continued technical progress and an evolving architecture for the space-based portion of Phase I now permit projected cost figures near \$55 billion (in constant FY88 dollars). This represents a continuing downward trend. In June 1988, at a DAB review, the direction of the SDI program was affirmed and the cost of a Phase I system was estimated to be \$115 billion. Significant technology advancements in many areas, coupled with results of previous system concept analyses, had led to a cost estimate dramatically reduced to \$69 billion at the next DAB review in October 1988.

Potential cost reductions are most significant for the space-based interceptor element. The architecture outlined for the DAB in 1988 had called for SBIs to be housed in Carrier Vehicles (CVs). Each CV was to contain a magazine of SBIs that would orbit the earth, ready on command to collide with and destroy Soviet ICBM boosters and post-boost vehicles. A SDIO-sponsored study was undertaken during the summer of 1989 to find ways to reduce the cost while increasing the effectiveness and survivability of the space-based element of the system. This study examined many different space-based architectures and identified one -- the Brilliant Pebbles (BP) approach -- as a promising concept to achieve the objectives for a SDS and one that may lower Phase I costs while maintaining the required level of effectiveness established by the Joint Chiefs of Staff for a SDS.

BRILLIANT PEBBLES

One of the first public descriptions of BP was presented in a March 1988 paper authored by Dr. Lowell Wood of the Lawrence Livermore National Laboratory in California. Unlike SBI, BP interceptors are designed to orbit the earth in a constellation of dispersed, individual interceptors, called singlets, each with its own imaging and computing systems, propulsion, station keeping, and communications. Like SBI, however, BP employs kinetic energy as its method of inflicting lethal damage on its target -- it contains no warhead, but rather destroys its target by the force of collision.

Features of BP include:

Small size, including, potentially, a total length of about one meter, a dry weight of less than ten pounds and a fully-fueled launch weight of about 100 pounds, thus requiring minimal space launch capability to deploy;

High capability/flexibility, deriving from pervasive use of existing or emerging commercial and military technologies. These include a set of miniaturized, high-resolution, wide field-of-view imaging systems working in multispectral bands, a CRAY-1 supercomputer-class data processing plant, and a light-weight propulsion plant;

Autonomous operability after release, as a result of high-performance imaging and computing systems, which would allow the interceptor to detect, identify, develop a high-precision estimate of position and velocity (track), and perform interception of targets after release commands;

Survivability, deriving from small size, autonomy and dispersal as singlets, which would provide low detection cross-section, jam resistance and low value per individual target. Survivability against a range of threats has been emphasized in the design of BP. Hardness against nuclear attacks is designed into the interceptor and is further leveraged by the interceptor's maneuvering capability, provided by its restartable, high-specific-thrust engines.

The BP navigation system is based on a novel, demonstrated, real-time stellar navigation module and standard miniature angular rate-sensing and linear accelerometers, backed by a high-precision clock. Each interceptor always has a highly accurate knowledge of where it is and where it's heading, simplifying interception capabilities. Its restartable propulsion system can be used to maintain any specified trajectory to whatever accuracy is required. Even if BPs are flown at low altitudes, station-keeping requirements permit them to fly such orbits for a decade before using an unacceptable fraction of on-board propellant.

Each BP would be launched with a "life jacket" to provide solar-derived electric power through a rechargeable battery, as well as thermal environment control. This life jacket would be discarded after the BP has been ordered to an intercept.

BP technologies, developed with SDIO funding to Livermore Lab, have involved extensive industrial-sector participation. Versions of some of these technologies have flown on SDIO's ARGUS NC-135 observation aircraft. A version of the supercomputing system is currently running the battle management software.

INDEPENDENT STUDIES

Because of the potential contribution of the BP concept to a robust defense system, SDIO Director Lieutenant General George L. Monahan, Jr., directed that several studies be conducted to examine thoroughly the prospect of introducing BP to the Phase I architecture. The studies and a summary of their findings are as follows:

A JASON Study was conducted in June and July 1989. JASON is a group of approximately 55 scientists dedicated to scientific and technical research and analysis in support of the national security community. JASON members, almost all of whom are university professors whose expertise and academic careers have been primarily devoted to theoretical and experimental physics and allied disciplines, are associated with over twenty academic institutions. The group endorsed the pursuit of further research on the concept of proliferated, small, light-weight, smart interceptors for ballistic missile defense. While some technical problems were identified, the group said it found no "show stoppers". The group commended Livermore's demonstrated technical accomplishments and expressed confidence that technical obstacles could be overcome.

A Defense Science Board (DSB) Study was conducted in June - September 1989. The DSB is a federal advisory committee established to provide independent advice to the Secretary of Defense. Membership includes top executives of defense industries and distinguished private consultants. The board found no fundamental flaws in the BP approach; they pronounced the idea innovative and capable. It cited several critical issues that require resolution, but predicted that two years of continued research would resolve those issues. The board recommended continuing pursuit of the BP project to maintain the pace

of innovation and improvement while maintaining the SBI program until the advantages and disadvantages of a BP system architecture are quantified. Such an approach would also serve as an aid to improvement of both designs. Further, the board recommended that an evaluation be conducted to understand fully the impact of BP on the SSTS and BSTS elements.

A Red Team/Blue Team study was conducted by experts assigned or under contract to SDIO to assess countermeasure issues. Results are classified, but fundamentally the group determined that BP would be subject to the same countermeasures as would all space-based elements. The key recommendation was to build survivability into the design.

An Air Force/SDIO Cost Study was conducted from May - December 1989. The study retained the $8 billion cost of BSTS confirmed by the DAB in October 1988, but examined the comparative cost of a SBI versus BP approach; launch costs also varied for the two concepts. The study determined that BP, SSTS and associated launch costs would be about $22 billion; the estimated cost for the Phase I system employing BP would, therefore, be about $55 billion, as opposed to $69 billion for Phase I with SBI.

The conclusions drawn from this series of studies can be summarized as follows:

* The October 1988 DAB system concept remains sound.

* Robustness of the system can be increased through proliferation and autonomy, and therefore the survivability, of the space-based elements.

* A distributed, autonomous space-based interceptor architecture is attractive and holds promise for cost savings, though further system refinement is required.

* While the role of SSTS may change somewhat in a BP architecture, it remains an important element of Phase I and should be vigorously pursued.

AIAA STUDY

In an independent study completed early in 1989 that performed a comprehensive technical review of all aspects of SDI except BP, the American Institute of Aeronautics and Astronautics concluded that "no issues were identified whose resolution could not be accomplished by the actions suggested [in the report], and no fundamental obstacles were found that a well-planned technology program could not surmount." The AIAA is a prestigious association of aerospace scientists and engineers. Their study included systems analysis and battle management; surveillance, acquisition, tracking and kill assessment; kinetic energy weapons; directed energy weapons; and support systems. The study found that "deployment of a Phase I strategic defense system able to meet the mission criteria defined by the Department of Defense depends on the resolution of technical issues that are currently being

addressed." Further, the study found that, "Should a future decision be made to deploy an SDS, resolution of the technical issues discussed in this assessment would permit such a system to be fielded."

MANAGEMENT APPROACH

The management approach in the coming months will be to exploit the unique capabilities of the national laboratories as well as U.S. and allied industry by providing maximum latitude to prepare a competitive program of design, development and production. SDIO will accomplish this through a program consisting of concept definition, pre-full scale development, full scale development, and finally production, if a decision is made to proceed. The key is to get industry involved early while preserving the simplicity and low-cost features of BP and encourage technical and programmatic innovation. Contractors already engaged by SDIO on BP technology research are TRW, Rockwell International, Martin Marietta, and Ball Aerospace. Conditions for success will include strong system integration, early emphasis on producibility and supportability, risk reduction, and architectural interfaces such as launch, and command and control. Livermore Lab will retain the innovator role throughout BP development and will drive early testing to support an informed deployment decision. The lab will also lead in the transfer of required technology for production to industry.

Planned tests for the coming years are intended to evaluate and validate technologies required for the BP concept. There will be a series of ongoing ground tests of computer, propulsion and sensor systems, as well as participation in above-ground and underground survivability tests. Twelve flight tests will address integration, terminal homing, life jacket design, and communications.

The first flight of a Brilliant Pebble is scheduled by this summer, on a suborbital flight. The U.S. Defense Department has ruled that the test complies with the Anti-Ballistic Missile Treaty of 1972, which bans anti-missile weapons in orbit.

SUMMARY

The technology for elements that could comprise a Phase I SDS is rapidly advancing. That reality is supported by many independent evaluations conducted by respected members and groups within the scientific and engineering communities. To be sure, the engineering task ahead is challenging, but achievable through innovative and well-managed research. To that end, SDIO will continue to pursue down-scoped SBI research designed to bring to fruition in the next one to two years the many technical endeavors underway with applicability to BP, while aggressively investigating and testing technologies that may enable Brilliant Pebbles to become the space-based interceptor of the Phase I architecture. At the same time, the function and design of the SSTS constellation will be revised to ensure maximum synergy with other elements of Phase I. It remains the intent of the Department of

Defense to improve global stability through cooperative transition from deterrence on the basis of the threat of massive retaliation to a world more reliant on deterrence provided by defensive systems.